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A SPOTTING OF CITRUS FRUITS DUE TO THE ACTION OF OIL LIBERATED FROM THE RIND

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A SPOTTING OF CITRUS FRUITS DUE TO THE ACTION OF OIL LIBERATED FROM THE RIND*

By HOWARD S. FAWCETT

Among the various spots and blemishes of lemons and oranges due to many different causes, there is one that is characterized by a slight sinking of the tissue between the oil glands in the rind leaving them standing out prominently over the surface of the affected areas. These spots vary greatly in size and shape. They are usually circular in outline and ordinarily do not exceed one-half an inch in diameter. They may, however, be irregular in outline and at times involve the greater portion of the surface of a fruit. At least one of the causes of such spotting has been found by Mr. J. D. Culbertson and the writer to be due to the remarkable and unexpected effect of small quantities of oil liberated from the glands in the rind. The oil liberated from the rind by any cause appears to act powerfully and quickly upon all the cells at the surface with which it comes in contact, except those immediately surrounding the oil glands. This leaves the oil glands standing out prominently over the surface of the area occupied by the spot. (Figs. 1 and 2.)

OCCURRENCE AND LOSSES

The greatest trouble from this spotting appears to occur in the lemon packing houses, especially in moist cool weather, during the rainy season. At that time, severe losses are often experienced by what is known as the "green spot." The lemons which come to standard size while green appear normal when picked, but on being set aside to cure develop spots which remain green while the remainder of the rind colors normally. (Fig. 2.) Such fruits may be kept for weeks without enlargement of the spots and without change in their green color. Sometimes the green is replaced after a long time by a reddish or brownish color, but the normal color does not develop in the spots. This lowers the grade of the fruit, but usually does not injure seriously its keeping quality. Lemons that have already colored before they are picked, may in some cases show spots of the same kind, though not green and therefore less conspicuous.

* Paper No 23, Citrus Experiment Station, College of Agriculture, University of California, Riverside, California.

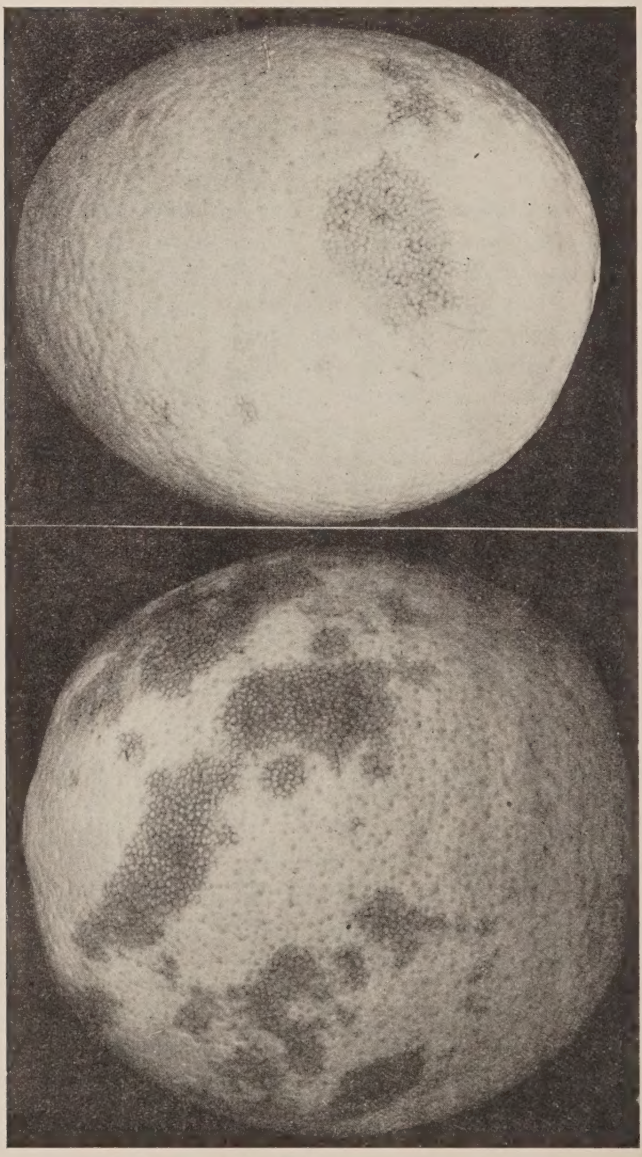

Fig. 1.—Immature oranges picked in November, showing the manner in which the cells between the oil glands are broken down, leaving the oil glands standing out prominently over the surface of the green spots.

(Photographed by J. T. Barrett.)

Oranges picked too early or when they are immature may also be severely affected by the "green spot." (Fig. 1.) Whether or not the so-called "brown spot" that has caused much trouble in past years during the winter months, is due in part to this cause has not been determined.

EXPERIMENTS AND OBSERVATIONS LEADING TO THE CAUSE

The experiments of Mr. J. D. Culbertson of the Limoneira Company, Santa Paula, California, led to the discovery of at least one cause of this green spotting. More than a year ago he produced what appeared to be typical green spotting on lemons by pressing and rolling them against boards. After putting them away for some weeks, apparently typical green spots developed. At that time the spotting was thought to be due to the injury to the cells themselves rather than to the oil. It was also noticed at that time that fruit picked from branches that had been cut off in pruning and were lying on the ground developed more green spotting than others picked directly from the trees. Other lemon growers had noticed that fruit picked when dark green and wet usually developed more "green spot" than similar fruit picked dry from the same trees. Mr. Culbertson states that in washing a lot of lemons picked late in November, 1914, while still wet with an early morning shower, a strong smell of lemon oil was detected by the men at the washer as the fruit came through the washing machine and that inspection of these lemons later showed them to be severely injured from green spotting. This led them to suspect that lemon oil itself might be responsible for the trouble, and early in December, just after a shower, Mr. Culbertson injured some lemons hanging on the tree so that the oil ran out over the uninjured surface, and also placed some of this oil on the uninjured surface of other fruits. The sinking of the tissue as in the green spot took place, but the green color did not appear as it did on the stored fruit. It was later found in our experiments that the green color rarely remained on spots injured by lemon oil if the fruit were left on the tree, but that if it were picked and stored the green color usually remained fixed.

Dr. J. T. Barrett, in making observations in Tulare County in December, 1913, noticed on the trees many fully colored oranges with spots that probably had been typical green spots (or would have been had they been picked earlier), that by remaining on the tree had assumed almost the normal color of the fully colored rind.

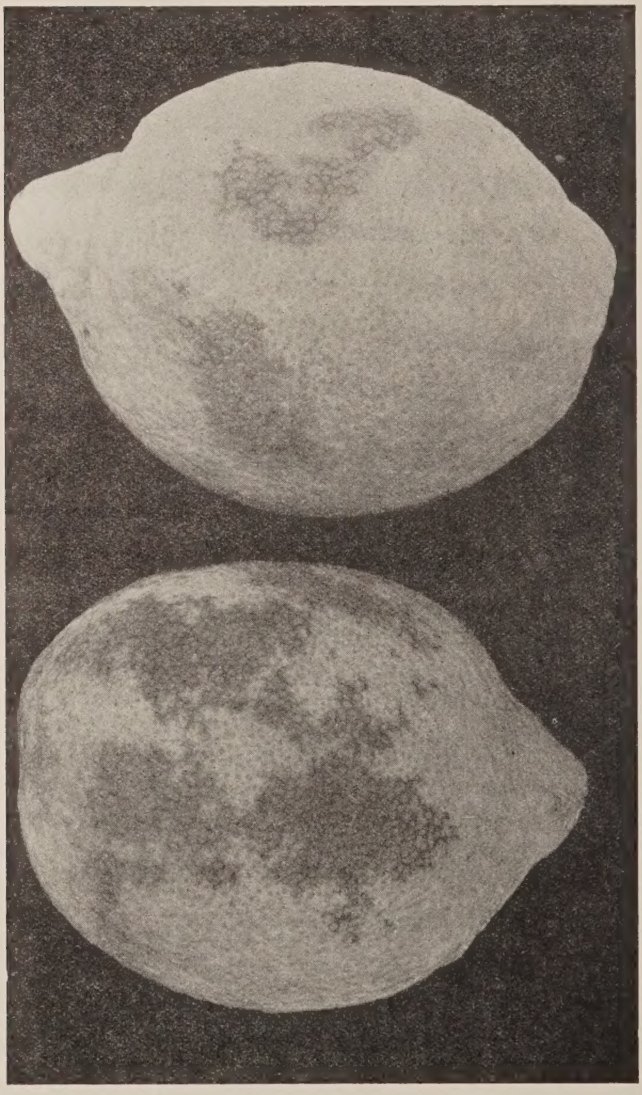

Fig. 2.—Cured lemons in November, showing the same type of spots as in figure 1. The darker areas indicate the green spots that have developed in the usual process of curing.

(Photographed by C. O. Smith.)

FURTHER EXPERIMENTS WITH LEMON AND ORANGE OIL

In an experiment by the writer, begun in February, 1915, the typical green spots were developed by very small amounts of lemon oil acting on the uninjured surface of green lemons in moist jars. Twelve lemons were picked very carefully to avoid any injuries on February 17, 1915, while they were still wet from a rain. Three lots of four each were placed in moist jars. On the uninjured upper surface of the first lot, a small amount of oil from a portion of the peel of another green fruit was squeezed out by hand. A small area on the rind of each of the second lot was pressed with the blunt end of the flat handle of a scalpel until oil was seen to appear on the surface. The third lot was left untreated as checks. The jars were kept covered to retain the moisture. On March 18, 1915, all the fruits in the first lot on which the lemon oil had remained on the uninjured surface showed typical spots where the oil had broken down the tissue between the oil glands. On two, the spots were green and on the others, they were reddish to brownish. The portion of the surface unspotted was coloring in the normal way. The second lot of fruits which had been pressed with the end of a scalpel, showed the same kind of spots. The spots were larger that the actual area pressed by the scalpel handle due to the spreading of the oil over the uninjured surface beyond the bruised spot. On the third lot kept as checks no spotting occurred.

Another experiment with lemons to compare the effect of lemon oil on dry and moist fruits was begun March 4, 1915. Four jars with four fruits each were prepared. For the first, the green fruits freshly picked from the trees were put in dry without washing and the lemon oil squeezed on a portion of their uninjured surfaces and the jar left open. For the second, the fruit was first washed and placed in the jar wet and the lemon oil squeezed on as in the first and the jar covered. The third and fourth jars were for checks, the fruit for one being put in dry and the jar left open, and the fruit for the other being washed and the jar covered. Three out of four of the first lot kept dry showed spots on March 18th, only one of which was green. All in the second lot kept wet, showed typical spots while none of the fruits on which no lemon oil was squeezed in the two check jars showed any spots.

Besides experiments with oil squeezed directly from the living rind of other fruit, experiments were also tried with measured quan-

tities of commercially expressed lemon oil.* This lemon oil acted on the rind in the same manner as the oil squeezed directly from the living rind.

In conducting experiments with lemon oil, it was observed that the action of the oil in breaking down the tissue was very rapid. In order to find out something as to the length of time necessary for the oil to produce visible injury, the following experiment was tried:

Nineteen full-sized light green lemons were placed in a row on the table in the laboratory and drops containing one one-hundreth (0.01) of a cubic centimeter were dropped on each. The drop on the first was rubbed off immediately with a piece of cotton. The other drops were rubbed off after they had remained on the rind different periods; namely, 3, 6, 7, 8, 9, 10, 15, 20, 30, and 45 seconds; 1, 2, 5, 10, 20, and 30 minutes; 1 and 2 hours, respectively. A visible effect of the oil was seen in a very short time on those left on two or more minutes. On the one on which the oil had acted 2 minutes a slight effect was visible in 20 minutes after the oil was rubbed off, and on the one on which the oil had acted 5 minutes, the effect was visible in 10 minutes after the oil was rubbed off. In 24 hours the fruit on which the oil had acted for approximately 8 seconds, showed a slight effect. On all those on which the oil had acted less than 8 seconds, no effect was visible, even after several weeks. The severity of effect was in proportion to the length of time the oil had acted upon the rind with slight variations, probably due to differences in the fruit. The experiment showed clearly that the action of the oil in breaking down the surface cells is extremely rapid.

During the months of March and April, a large number of different experiments were carried out by putting different quantities of lemon and orange oil from the rind on more than 150 fruits of all ages of both lemons and oranges. The effect of the oil was further compared in both moist and dry atmosphere on fruit both on and off the tree. The effect of the oil was also tested on young shoots, leaves and flower buds. The following is a summary of the results of the various experiments:

1. The effect of a given amount of oil from the rind was greater on fruit in a moist atmosphere than on similar fruit in a dry atmosphere.

2. The moisture being the same, the effect was greater on green or immature fruit than on fully colored or mature fruit.

* I am indebted to Mr. C. P. Wilson, of the Citrus By-Products Laboratory of the Bureau of Chemistry, United States Department of Agriculture, Los Angeles, California, for two samples of lemon oil for use in the experiments.

3. The effect was greater on fruit just picked than on similar fruit picked for some days.

4. The action of small amounts of oil, for example, such as could be liberated by a hard pressure of the thumb against the rind of a dark green freshly picked moist lemon (or by .01 cc. of the commercially expressed lemon oil), was sufficient to cause the typical green spotting. The green color appeared to be fixed in the portion acted on by the oil while the remainder of the rind colored normally in the usual process of curing in four to six weeks.

5. The action of a large amount of lemon oil, such as one-tenth of a cubic centimeter or more, under the same conditions caused the spots to become brownish or reddish rather than green. When the amount was sufficiently increased the breaking down of the tissue was so great that blue mold started in a few days.

6. When the fruits acted on by the oil were left attached to the tree, only in rare cases did the green color remain. As the fruits continued to grow and mature, the sunken areas were partially restored and only slight scars were left.

7. Under similar conditions the oil from the rind of oranges acted upon other uninjured oranges in the same manner as did the oil from the rind of lemons act upon other lemons.

8. The oil caused the spotting of tender leaves and shoots and the withering of flower buds when squeezed out upon them.

9. The action of the oil on the surface of the rind is extremely rapid, as shown by the fact that one one-hundreth of a cubic centimeter of lemon oil acting for eight seconds was sufficient to show afterward a visible effect on the rind.

The results of these experiments aid us in explaining some of the following observed facts in connection with the occurrence of the so-called green spot.

Green spotting has been observed almost exclusively on fruit picked during the late fall, winter and early spring. This in general corresponds to the season of moist atmospheric conditions in California due to frequent rains and fogs. It has also been observed, as stated before, that fruit picked while wet after a rain is more apt to spot than that picked dry. The experiments have shown that the same quantities of oil, other things being equal, has more effect in a moist than in a dry atmosphere, on wet than on dry fruit. The lemons picked at the above mentioned season are apt to contain a higher percentage of dark green fruit that at other seasons. The experiments have also shown that the oil had more effect on green than on ripe fruit. The explanation would therefore appear to be this; that in the process of

picking and handling, certain small amounts of oil are liberated on the surface of the rind, and that this oil is able to cause severe spotting in a moist atmosphere or when the fruit is wet, as is often the case during the rainy season, especially when it is green. That no serious trouble from green spotting is experienced in summer is probably due to the dryer atmosphere and the greater maturity of the fruit. In a dry atmosphere the oil would quickly volatilize and therefore have little time to act.

Then there occur spots on fruit on the tree in connection with scratches or bruises from passing teams that in size appear to be out of all proportion to the mechanical injury inflicted. In many cases an area may be traced where the oil has spread out from the broken cells affecting the adjacent tissue in the same manner as in the spotting under consideration. It also seems probable that in like manner the injury following red spider, and other mites and insects is emphasized by the liberation of oil. The injuries due to the whipping of the fruit against the branches by the wind in severe storms are also probably more severe for the same reason.

It has also been observed by packing-house men that there is great variation in the spotting between fruit from various groves handled under the same conditions. This may be due in part to variations in maturity or growth conditions of the fruit that might modify the structure of the rind and possibly the amount of oil in it. The oil is probably liberated much more easily from fruits from certain groves than others, due possibly to these differences in the fruit itself.

REMEDIES

One very obvious remedy is to avoid picking fruit when wet either with rain or dew. That this has proved to be a practical remedy in some cases is shown by the following examples.

Mr. Culbertson of the Limoneira Company, Santa Paula, writes: "Since the first of December we have carefully avoided picking lemons too soon after a rain or extra heavy dew, until it developed that we were getting practically no green spot. The disappearance of the spot later was probably due also to the greater maturity of the lemons."

Mr. M. Perry of the Teague McKevitt Ranch, showed the writer two sets of lemons, one set picked in the early morning after a rain, the other picked from the same trees and by the same pickers near the middle of the same day when the fruit was dry. The first lot picked

wet was badly spotted; the second, picked dry, showed only an occasional spot.

Another remedy that suggests itself, is extreme care in handling the fruit to avoid injuries or knocks that would tend to liberate the oil in the rind. It has been recognized for a long time that great care in handling the fruit is necessary in avoiding decay from blue mold. To avoid green spotting on susceptible fruit during the critical season even greater care will doubtless be necessary. Pressing together of the fruit in the picking sacks, letting them drop too far into the field boxes, jolting in wagons without springs on rough roads, rough knocks and jamming in washing, grading and packing are all means that would tend to liberate the oil from the rind.

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